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PEDCo-Environmental, Inc.
Cincinnati, OH

Prepared for

Industrial Environmental Research Lab.
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SUMMARY OF COAL-BASED SYNTHETIC FUEL INITIATIVES

by

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Project Officer: Michael K. Bergman
Coal Technology Assessment

Prepared for

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Office of Environmental Engineering Technology
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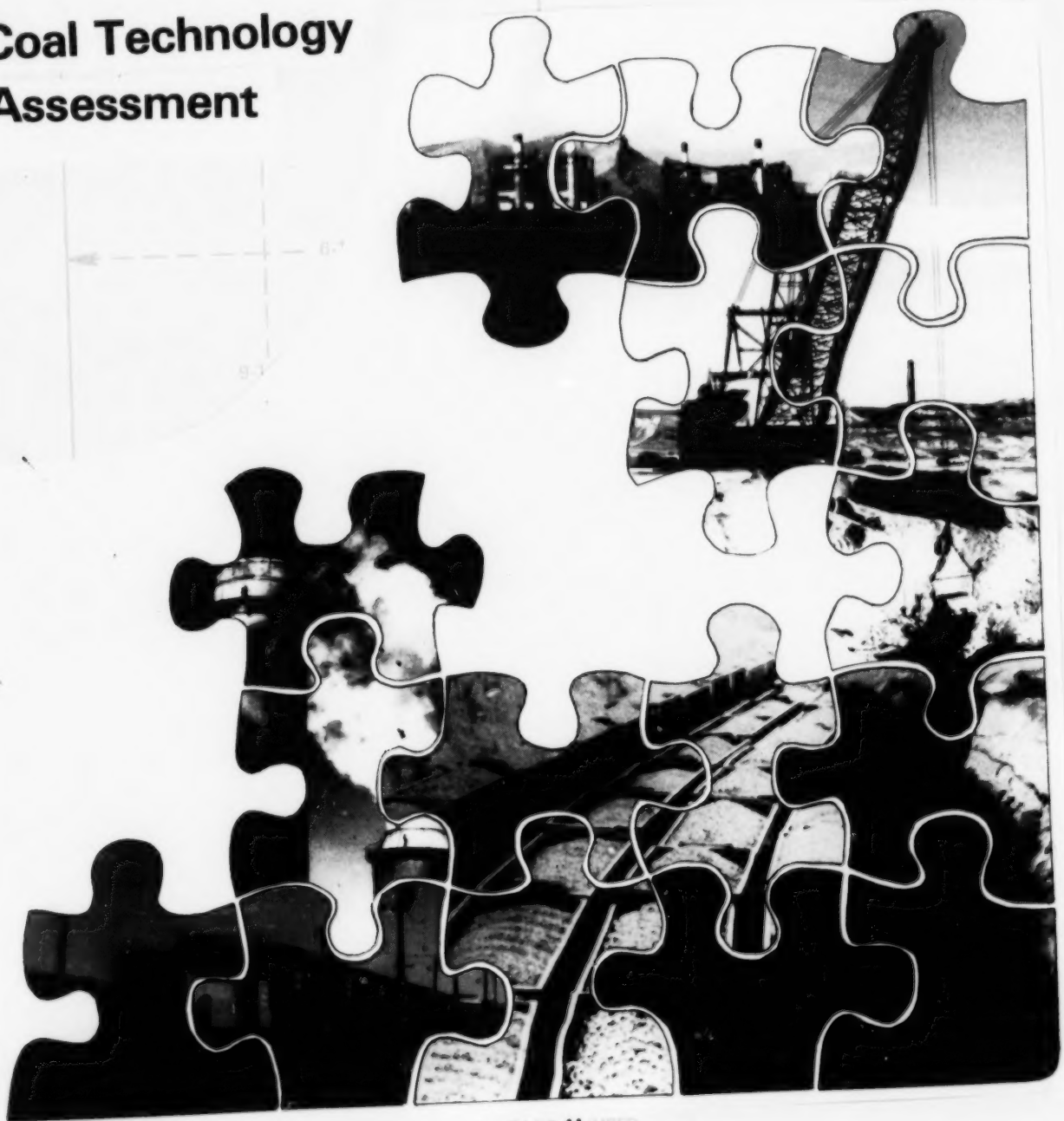
Summary of Coal-Based Synthetic Fuel Initiatives

Coal Technology Assessment



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Abstract

This document was prepared to assist the Office of Environmental Engineering and Technology of the Environmental Protection Agency in the collection and verification of information on the status of demonstration and commercial-scale plants for the production of coal-based synthetic fuels through gasification and liquefaction. Data on the scope of this emerging industry, funding sources, products, and costs were obtained by reviewing current literature and contacting the primary vendors or licensors of the processes found. These data are as reported; no modifications have been attempted.

Of the 88 synthetic fuel projects identified, 66 represent gasification processes (29 for the production of low-Btu gas and 37 for the production of high-Btu gas), and 22 represent liquefaction processes. One tabulation shows the breakdown of these projects by process and status as of mid-August 1980. Maps show their locations throughout the United States. Furthur tabulations show sponsors, production capacity, estimated production costs, scale, type of coal involved, feed rate of coal, capital cost, and operation and maintenance costs.

The report also contains a brief commentary of each of the identified projects.

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SECTION 1

INTRODUCTION

The Office of Environmental Engineering and Technology (OEET) of the Environmental Protection Agency (EPA) is sponsoring the national Coal Technology Assessment (CTA) program to investigate important environmental, social, economic, institutional, and regional concerns arising from the future use of conventional and advanced technologies to produce energy from coal. The CTA is but one of the major studies in EPA's Integrated Technology Assessment program. The CTA project is conducting studies of the various sectors of the economy that use or might utilize coal-based energy, one source of which is the synthetic fuels industry. This document was prepared to assist the CTA in collecting and verifying information on initiatives in building and operating demonstration and commercial scale plants for producing coal-based synthetic fuels through gasification and liquefaction only. Based on data accumulated through the second week in August 1980, the information presented gives an indication of the scope of the newly forming industry, the funding sources, and the products. With particular respect to synthetic fuels, a major report to be produced from the Coal Technology Assessment will also address some of the managerial challenges facing the initiation of a large-scale synthetic fuels industry. Other reports in the major CTA report series will compare synthetic fuel technologies with other coal-based energy technologies.

The synfuels industry is gaining attention in the United States as petroleum and natural gas resources are being depleted and becoming uncertain supplies of energy. The industry is growing to meet the nation's energy needs for potentially clean and reliable sources of fuels from proven reserves. Coal-derived synthetic fuels have been studied for several years and, as additional processes are developed, proven, and constructed, the reliability of the concept increases. Technologies now exist to enable all types of coal

to be converted into gaseous and liquid fuels, as well as chemical feedstocks, thus reducing somewhat our nation's dependence on foreign sources of energy. The advisability of pursuing these technologies is not addressed in this report.

The present state of activity in the synfuels industry is indicated by the large number of applications submitted to the Department of Energy for consideration in the $200 million fiscal year (FY) 1980 grants for feasibility studies and cooperative agreements in the synthetic fuels area. DOE announced that it had received 951 applications from industry for aid in funding synthetic fuels projects. Less than 20 percent, however, were for coal-derived synthetic fuels, the majority being alcohol fuels projects. In early July 1980, DOE announced 110 recipients of the $200 million grant money. Eleven projects received cooperative agreements, three of which were coal-related projects receiving a total of $59.5 million. The remaining grants were for feasibility studies. Coal gasification projects received a total of $56 million in grants; coal liquefaction received a total of $45 million. It is interesting to note that relatively few applications were submitted pertaining to oil shale projects and this area received only $13 million. DOE is now planning to receive a second round of solicitations in early October. The second round of grant allocations are for $100 million in feasibility study funds and $200 million in cooperative grants.

With the huge response to develop alternate fuels, the need for continuing knowledge of the current status of the projects becomes apparent. Environmental issues surrounding the industry must be addressed, as well as demand for the product and the cost to construct and maintain the facilities. The information presented herein was collected by reviewing current literature and contacting the main vendors or licensors of the processes found. No new work has been performed other than to compile the lists included and to report and summarize the available information. All information contained in this report is reported as found and, unless a more reliable source was found, no modification of the data was made. Some of the data found are less reliable than others, especially in the category of cost estimation. Because very few plants are operating on a commercial scale, there is a lack of operation and maintenance costs for these projects. Some data have been obtained, however, from the licensors.

BACKGROUND

Coal can be converted to clean gaseous and liquid fuels through gasification and liquefaction, respectively. The basic reactions and unit operations involved in these two processes are briefly summarized below.

Gasification

The conversion of coal to gaseous products involves four chemical reactions: devolatilization/pyrolysis, gasification, combustion, and water-gas shift reaction. Heat required to promote the first two reactions is supplied by air or oxygen. The gas produced will be low-Btu (150 Btu/scf) if air is used, and medium-Btu (350 Btu/scf) if oxygen is used. If an additional step of methanation is used, synthetic natural gas (SNG) will be produced with a heating value of about 1000 Btu/scf.

Gasification systems consist of three main areas: coal pretreatment, coal gasification, and gas purification. The coal pretreatment will vary depending upon the coal type and the gasifier design. The gasifiers can be classified as fixed-bed atmospheric (or pressurized) dry ash, fixed- or entrained-bed pressurized slagging ash, entrained-bed atmospheric slagging ash, and fluid-bed atmospheric dry ash. The gas purification scheme will vary depending upon the desired end use of the product gases. Generally, the gas purification step involves particulate collection, quenching and scrubbing, and acid gas removal.

Liquefaction

All liquefaction processes consist of five major areas: coal pretreatement, coal liquefaction, separation, purification and upgrading of products, and auxiliary processes. Liquid fuels are produced by yielding a material having higher hydrogen content than coal. The direct liquefaction processes can be classified as hydrogenation, pyrolysis and hydrocarbonization, and supercritical gas extraction. Depending upon the process, hydrogen is added to the coal components, or hydrogen-rich components are stripped from the coal. The hydrogen increase is not completed in the initial reaction. Hydroheating is required to upgrade the product and also to reduce sulfur, nitrogen, and oxygen content. Varying amounts of carbon remain as a char, depending upon the process. In some systems, this char is used to generate hydrogen by the steam carbon reaction.

Indirect liquefaction processes use synthesis gas in place of hydrogen. The synthesis gas (mixture of hydrogen and carbon monoxide) is produced by the gasification of coal. The gaseous products are then catalytically converted to liquid fuels.

In general, liquefaction processes offer several advantages over gasification. The overall thermal efficiency is usually higher and process water requirements are reduced. Liquefaction processes operate under less severe temperature and pressure conditions than gasification processes.

SECTION 2

SUMMARY OF FINDINGS

A total of 88 projects have been identified which convert coal to another form of usable fuel. Of these, 29 are low-Btu projects, 37 are medium- or high-Btu projects, and 22 are liquefaction projects. A summary of the projects, including the type of process and status of the project, is given in Table 1. The locations of these projects vary somewhat, with the main concentration of proposed sites being located in Pennsylvania, Kentucky, and the other Appalachian states, with relatively few projects occurring in the western states. The geographic locations of the projects identified are shown in Figures 1, 2, and 3.

The following section lists all of the projects identified along with comments on each project. The information most difficult to obtain is operation and maintenance (O&M) costs. These O&M costs are generally only available because of recent operating status or future operation. Some estimates of production costs for commercial plants are presented in Table 2. The costs in Column A are directly extracted from the source. Column C costs have been grouped based on the values reported to match the format in the first column. The ranges reported can be used as a general guideline in evaluating the accuracy of other estimates. These costs are generally representative of other reported costs. As the price of coal increases, however, the cost of the product will also increase. One reference reported that approximately 14 percent of the product cost goes to purchasing the coal.

Other factors also affect the cost of synthetic fuel production. Obviously, as the number of gasifiers increases, the cost increases. In addition, when oxygen is used instead of air (the main difference between medium- and low-Btu gasification) the cost also increases. However, almost 40 percent more Btu's are produced when using oxygen instead of air.

TABLE 1. SUMMARY OF IDENTIFIED COAL CONVERSION PROJECTS

Product	Process	Number operating[a]	Idle[b]	Number under construction	Number in design	Number in study	Number unknown	Total
Low-Btu Gas	Wellman-Galusha	8	1	3			1	13
	Wellman Incandescent	1					1	2
	Combustion Engineering	1				1		2
	Texaco	0			1	1		2
	Allis-Chalmers	1		1				2
	Chapman (Willputte)	1						1
	Foster Wheeler/ Stoic	1						1
	Riley Morgan	1						1
	Woodall-Duckman	0					1	1
	Westinghouse	1						1
	Tri-gas	1						1
	Gulf	1						1
	Unknown	0				1		1
Med-high Btu gas	Lurgi			2		10	1	13
	IGT-Hygas	1			2	2		5
	Texaco			1		2	1	4
	Bi-Gas	1						1
	Synthane		1					1
	COED-COGAS				1			1
	BGC		1					1
	Self-agglomerating ash	1						1
	Stearns & Rogers	1						1
	Hydrane		1					1
	Garrett	1						1
	Exxon	1						1
	Fischer-Tropsch					1		1
	Flash hydro-pyrolysis	1						1
	Unknown					4		4
Coal liquids	Fischer-Tropsch				1	1	1	3
	SRC-II	2		1				3
	H-coal	1				1		2
	SRC-I	1				1		2
	COED		1					1
	Clean coke	1						1
	Exxon Donor Solvent			1				1
	TOSCO II	1						1
	Clean Fuel From Coal (CFFC)	1						1
	Direct hydro-generation	1						1
	Flash pyrolysis		1					1
	Texaco & Mobil					1		1
	Mobil					1		1
	SASOL III					1		1
	Unknown					2		2

[a] On any scale.

[b] Operational at one time; now inactive or dismantled.

Figure 1. Location of low Btu gasification projects.
(See Table 4 for corresponding project ID numbers.)

Figure 2. Location of high Btu gasification projects.
(See Table 5 for corresponding project I.D. numbers.)

Figure 3. Location of coal liquefaction projects.
(See Table 6 for corresponding project I.D. numbers.)

TABLE 2. HIERARCHY OF SUPPLEMENTAL ENERGY SOURCES BY COST

Supplemental sources	Estimated price at point of production $(1979)/10^6 Btu	
	a,b	c,d
High Btu gas from coal (2nd generation)	4.00-5.50	3.45-4.22
Medium-Btu gas from coal (1st generation)	4.00-5.50	3.45-4.22
Solvent-refined coal (solid)	4.00-5.50	3.38-3.67
Crude shale oil (all processes)	4.00-6.00	-
High-Btu gas from coal (1st generation)	5.00-6.00	2.79-3.10
Low-sulfur heavy fuel oil from coal	5.00-6.00	3.30-3.89
Distillate fuel oil from coal	6.00-7.00	3.30-3.89
Methanol from coal	6.00-9.00	3.62-4.32
Gasoline from coal	8.00-11.00	4.84-5.41

[a] Source: Gas Research Institute. Reprinted with permission from Lee, B.S., President, Institute of Gas Technology. Synthetic Fuels and Total Cost of Oil Imports. IGT GaScope No. 50, September 1980.

[b] Processes included unknown.

[c] Source: Rogers, K.A., R.F. Hill. The Engineering Societies Commission on Energy, Inc. Coal Conversion Comparisons. Prepared for the U.S. Dept. of Energy, July 1979.

[d] Not all processes are included.

Many of the projects identified are in the feasibility study phase, and as such, do not have specific end-use plans. Generally speaking, the low-Btu gas will be used on site for either process heat, combined-cycle electricity generation, or kiln firing. High-Btu gas will be used as a direct substitute for natural gas in pipelines, chemical feedstocks, and feed to a liquefaction process. Some high-Btu gas will also be used for electricity generation. The SRC I and II liquids will be used as a substitute for boiler fuel oils, especially residual oil. Coal liquids will be used to produce liquid fuels such as methanol and gasoline. A summary of the reported production rates is given in Table 3. Additional information on the projects can be found in Tables 4, 5, and 6, and in Section 3 (additional information and commentary).

TABLE 3. SUMMARY OF SYNFUELS PRODUCTION[a]

Process	Number of values reported	Total 10^6 Btu/h equivalent	Total 10^3 BBl oil/day equivalent	Total 10^6 scf/day	Miscellaneous units
Low	11	292.3	-	7.5	708 MW
High	26	125,000	132	129,874	135[b]
Liquefaction	13		718		100[c]

[a] All values are summarized in units as given by the synfuel project contacts. The production values for each column are not equivalent. Applicable metric conversions follow:

10^6 Btu = 1.055 GJ
10^3 bbl = 159 m^3
10^6 scf = 26,300 Nm^3

[b] Fuel produced can be used to produce 135 tons of ammonia per day.

[c] Fuel produced can be used to produce 100 tons of gasoline per day.

TABLE 4. LOW-BTU GASIFICATION PROJECTS IN THE UNITED STATES

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
1	Texaco, Southern California, Edison, EPRI	Preliminary engineering complete in 1980, operation by 1983	Texaco	90-100 MW, equivalent to ~3500 bbl oil/day	Commercial/ demonstration	a	1000 tons/ day	Barstow, California (Daggert)	300	a	1,2
2	Combustion Engineering, DOE, Gulf States Utilities, EPRI	1st run in June 1978	Combustion Engineering	10 MW, or 750,000 std. ft^3/h	Pilot	a	120 tons/ day	Windsor, Connecticut	b	b	1,3,4
3	Illinois Power Co., Allis-Chalmers	Project to start in 1980, operations to begin mid-1983	Allis-Chalmers	400 MW	Demonstration	High-sulfur	820 tons/ day	East Alton, Illinois	135	a	1,5,6
4.	Pike County, Kentucky; DOE; Kentucky DOE; Appalachian Regional Commission	Complete in 1981	Wellman-Galusha	60 x 10^6 Btu/h	Commerical	Low sulfur bituminous	3 tons/h	Pikeville, Kentucky	5.8	a	1,3,7
5	General Refractories Co.	9-month proposal	Low-Btu	a	Feasibility study	a		Florence, Kentucky	b	b	8
6	Irwin Industrial Development Co., DOE	a	Wellman-Galusha	a	Commercial/ demonstration	Eastern Kentucky (0.8-2% sulfur)	1.5 tons/h	Georgetown, Kentucky	5.6	a	3
7	General Refractories Co., DOE	a	Woodall-Duckman	895 x 10^6 Btu/day	Commercial/ demonstration	Low-sulfurb	2 tons/h	Hitchins, Kentucky	4.3	a	3

(continued)

TABLE 4 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
8	Combustion Engineering, Gulf States Utilities	Contract being negotiated	Combustion Engineering	150 MW	Commercial	a	1800 ton/day	Lake Charles, Louisiana	100	$50 x 10^6/yr	1,9
9	Central Maine Power, Texaco, General Electric, Stone and Webster Engineering	Construction in 1983, operation in 1987, DOE feasibility funds	Texaco	48 MW equivalent to 16,000 bbl oil/day	Commercial	a	4600 ton/day	Sears Island, Maine	1000	a	10
10	Riley Stoker Co.	Tested	Riley Morgan	a	Commercial/demonstration	Several	a	Worchester, Massachusetts		a	7
11	Bureau of Mines, DOE, DOI	Tested in 1978, 1979	Wellman-Galusha	a	Commercial/demonstration	Kentucky and Montana bituminous, Colorado subbituminous, and North Dakota lignite	a	Fort Snelling (St. Paul), Minnesota		a	7
12.	University of Minnesota, DOE	Startup in June 1979	Foster Wheeler/Stoic (Lurgi-Stoic)	55-60 x 10^6 Btu/h	Commercial	Low-sulfur Wyoming bituminous	a	Duluth, Minnesota	5.5	a	1,3,7
13.	Lands O' Lakes Creamery, DOE	a	Wellman-Incandescent	40 x 10^6 Btu/h	Commercial/demonstration	Utah (<1% sulfur)	3 tons/h	Perham, Minnesota	6.5	a	3
14	National Lime and Stone Co.	Operating since 1955	Wellman-Galusha	a	Commercial	Bituminous (0.7% sulfur)	a	Carey, Ohio	a	a	1,7
15	Glen-Gary Brick Co., Acurex-Aerotherm Co., DOE	Operating	Wellman-Galusha	a	Commercial	Anthracite (0.7% sulfur)	a	Reading, Pennsylvania	a	a	7
16	Glen-Gary Brick Co., Acurex-Aerotherm Co., DOE	Operating	Wellman-Galusha	a	Commercial	Anthracite (0.7% sulfur)	a	Shoemakersville Pennsylvania	a	a	7

TABLE 4 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
17	Glen-Gary Brick Co., Acurex-Aerotherm Co., DOE	Operating	Wellman-Galusha	a	Commercial	Anthracite (0.7% sulfur)	a	Watsontown, Pennsylvania	a	a	7
18	Glen-Gary Brick Co., Acurex-Aerotherm Co., DOE	Operating since 1953, additional Unit in 1977	Wellman-Galusha	a	Commercial	Anthracite (0.7% sulfur)	1 ton/h	York, Pennsylvania	1.5	a	1,3,7
19	Glen-Gary Brick Co., Acurex-Aerotherm Co., DOE	Operating	Wellman-Galusha	a	Commerical	Anthracite (0.7% sulfur)	a	New Oxford, Pennsylvania	a	a	7
20	Hazelton Brick Co.	Operating since 1953	Wellman-Galusha	a	Commercial	Anthracite (0.7% sulfur)	a	Hazelton, Pennsylvania	a	a	1,7
21	Binghamton Brick Co.	Not currently operating	Wellman-Galusha	a	Commercial	Anthracite (0.7% sulfur)	a	Binghamton, Pennsylvania	a	a	7
22	Hownet Aluminum	To be completed in 1980	Wellman-Galusha	a	Commerical	Anthracite (0.7% sulfur)	a	Lancaster, Pennsylvania	a	a	7
23	Can Do, Inc.; DOE; DOI	To be completed in 1980	Wellman-Galusha	a	Commercial	Low-sulfur anthracite	a	Hazelton, Pennsylvania	a	a	1,7
24	Caterpillar, Inc. Black, Sivalls, and Byson, Inc.	Startup in October 1979	Wellman Incandescent	2.4×10^9 Btu/day	Commercial	Bituminous	130 tons/day	York, Pennsylvania	a	a	1,7
25	Bituminous Coal Research, Inc.; DOE	Operating since 1976	Tri-Gas	a	Pilot	Illinois No. 6 (Rosebud)	100 lb/h	Monroeville, Pennsylvania	b	b	3,11

TABLE 4 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
26	Energy Systems Group, Rockwell International; DOE	First run in November 1978 (15 tons/day)	Westinghouse Electric Corp.	a	Pilot	a	15-120 tons/day	Waltz Mill, (Madison), Pennsylvania	b	b	3
27	Holston Army Ammunition Plant	Operating since 1940	Chapman (Wilputte)	a	Commercial	Bituminous (0.6% sulfur) anthracite	a	Kingsport, Tennessee	a	a	1,7
28	Illinois Power Co., Allis-Chalmers	Operating since 1971	Allis-Chalmers	a	Pilot	a	60 tons/day	Oak Creek, Wisconsin	a	a	1
29	Gulf, DOE	Five year study in progress; operation at mine	Gulf	250,000 ft^3/ton coal	Pilot	Wyoming subbituminous	30 tons/day	Rawlings, (North Knobs), Wyoming	b	b	12

[a]Data not available.

[b]See text.

Applicable metric conversions:

10^6 Btu = 1.055 GJ
10^3 bbl = 159 m^3
10^6 scf = 26,300 Nm^3

TABLE 5. HIGH-BTU GASIFICATION PROJECTS IN THE UNITED STATES

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
1	TVA	Startup in mid-1980	Texaco	135 tons ammonia/day	Commercial, medium-Btu	Bituminous	200 tons/day	Muscle Shoals, Alabama	43.2	a	1,13
2	TVA, Bechtel National, C.F. Braun, Foster Wheeler	Preliminary design complete by 1989, one phase hoped to be on line in 1985	Texaco, Koppers-Totzek, Lurgi, British Gas, or Babcock & Wilcox	Equivalent to 50,000 bbl oil/day	Commercial, medium-Btu	Illinois or Kentucky	20,000 tons/day	Murphy Hill, Marshall Co., Alabama	1000 - 2000	a	10,14
3	Arkansas Power & Light	Feasibility study request to DOE for $\$3.7 \times 10^6$	Texaco	Equivalent to 25,000 - 30,000 bbl oil/day	Commerical, medium-Btu	Illinois No. 6, Arkansas	a	Redfield, Arkansas	a	a	15
4	Occidental Research & Development Company	Operating	Garrett Process		Bench	Western Kentucky	3.6 tons/day	LaVerne, California	a	a	16
5	Pacific Gas & Electric	Feasibility study being requested	Texaco & Lurgi	1×10^9 ft^3/day, equivalent to 60,000 bbl oil/day	Commercial/ demonstration	Wyoming and Utah	17,000 tons/day	Collinsville, California	800[b]	b	17
6	Institute of Gas Technology, DOE, State of Kentucky, GRI	Operating since 1973	IGT-HYGAS	1.5×10^6 std. ft^3/day	Pilot	Missouri No. 10 (Peabody), Illinois No. 6 (Rosebud)	75 tons/day	Chicago, Illinois	b	b	1,3,4,16
7	Columbia Gas System, Inc. Inc.	Economic/ technical feasibility study	a	300×10^6 ft^3/day	Commercial	a	a	Illinois	a	a	18

TABLE 5 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
8	Illinois Coal Gasification Group, Dravo Corp., DOE	Construction scheduled to start in 1981 and be completed in 1984	COED-COGAS	18 x 10^6 std. ft^3/day and 2400 bbl syncrude/day	Commercial/ demonstration	a	2210 tons/ day	Perry Co., Illinois	334	a	1,16,18
9	Texas Gas Transmission Corp.	Feasibility study completed, planning in progress	HYGAS	85 x 10^6 ft^3/day	Commercial	a	7500 tons/ day	Western Kentucky	a	a	18
10	Texaco, Houston Natural Gas	Feasibility study funds requested	Texaco with methanation	300 x 10^6 ft^3/day and 25 x 10^3 bbl methanol/day	Commercial, medium-Btu	a	6000 tons/	Convent, Louisiana	500	a	10
11	Washington Energy Company (Natural Gas)	Preliminary feasibility study under way	Lurgi	275 x 10^6 ft^3/day (heating value of 250 x 10^9 Btu/day)	Commercial	Montana lignite	13 x 10^6 tons/yr	McCone Co. (near Circle), Montana	2000-2500	a	17,18
12	Montana Power Company, Montana-Dakota Utilities Co., Air Force	Proposal for feasibility study under review by Air Force	HYGAS or similar	30-100 x 10^6 ft^3/day	Commercial	a	a	Montana-Dakota area	b	b	18,19
13	DOE, FERC	Operated 1958-65 under Bureau of Mines, 1977 contract to S-R, Inc.	Stearn-Rogers, Inc., with slagging gasifier	a	Pilot	Bituminous	1 ton/day	Grand Forks, North Dakota	b	b	16
14	Natural Gas Pipeline Company of America	Phase I engineering complete; no filing yet; further action deferred	Dunn Center Project Lurgi with methanation	250 x 10^6 ft^3/day	Commercial	a	30,000 tons/ day	Dunn County, North Dakota	a	a	16,18

TABLE 5 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
15	ANG Coal Gasification, American Natural Resources Co. Mich-Wis Pipe-Line Company, Great Plains Gasification Associates	To be completed in 1984	Lurgi-fixed bed with methanation	137.5 x 10^6 ft^3/day	Commercial	Lignite	14,000 tons/day	Beulah, North Dakota	1.5 x 10^3[b]	5.66/10^3 ft^3	1,4,8,16 18,20
16	Texas Eastern Transmission, Pacific Lighting Corp.	Preliminary feasibility study under way	Lurgi with methanation	250 x 10^6 ft^3/day	Commercial	a	a	Northwest New Mexico	a	a	16,18
17	Texas Eastern Synfuels, Utah International	Proposed 9-month study	Lurgi-gas and methanol		Feasibility study	a	25,000 tons/day	San Juan Co., New Mexico	b	b	1,8,13
18	El Paso National Gas Company, Pacific Gas & Electric	Application expected in 1980-1981	Burnham Project, Lurgi with methanation	72 x 10^6 ft^3/day	Commercial	a	7600 tons/day	Northwest New Mexico			16,18
19	Battelle Memorial Institute, AGA, DOE	Constructed in 1978; limited testing	Self-agglomerating ash	a	Pilot	a	25 tons/day	West Jefferson, Ohio	a	a	16
20	Texas Eastern Corporation	Preliminary feasibility study under way	Fischer-Tropsch	a	Commercial	a	a	Ohio Valley	a	a	18

TABLE 5 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
21	Conoco Coal Development Co., DOE, Gulf, Sun, Tenneco, EPRI, Panhandle National Gas Pipeline, Texas Eastern Co., DOE	Completed by 1984; full operation by 1987	BGC-Lurgi slagger (Foster Wheeler)	19-59 x 10^6 std. ft^3/day	Commercial/demonstration	Ohio No. 9 (4.5% sulfur)	1250 - 3800 tons/day	Caldwell (Noble Co.), Ohio	340	8.49/10^6 Btu	1,16,18
22	Bituminous Coal Research, Inc., American Gas Association; Phillips Petroleum; DOE	Operating since 1976	Bi-Gas	2 x 10^6 std. ft^3/day	Pilot	a	120 tons/day	Homer City, Pennsylvania	b	b	1,3
23	Lummus Company, DOE	Operation began in 1976, currently on standby	Synthane	a	Pilot	Illinois No. 6	72 tons/day	Allegheny Co. (Bruceton), Pennsylvania	41.5	a	1,3,16
24	DOE, Rocketdyne, Dravo Corp.	Operating before 1978, contract expired in 1978	Hydrane	a	Bench	a	10 tons/day	Bruceton, Pennsylvania	a	a	16
25	Philadelphia Gas Works	Feasibility study	Medium-Btu	Equivalent to 4000 bbl oil/day	Commercial	a	a	Northeast Philadelphia, Pennsylvania	125	a	21
26	Conoco Coal Development Co., DOE	Constructed in 1972; testing completed in 1977	CO_2-Acceptor BGC	a	Pilot	Ohio dolomite; South Dakota lignite or subbituminous	40 tons/day	Rapid City, South Dakota	a	a	4,16

TABLE 5 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
27	Memphis Light, Gas, and Water; Foster Wheeler Delta Refinery; DOE; IGT	Preliminary work completed, construction to begin October 1980, unit to be operational by 1984	IGT-U-Gas	154 x 10^6 ft^3/day	Commercial/ demonstration medium Btu	Kentucky No. 9 (high sulfur bituminous)	3100 tons/ day	Memphis, Tennessee	700[b]	a	1,18,22
28	Exxon Co.	Operating, commercial plans deferred	Exxon	a	Bench	a	0.5 ton/day	Baytown, Texas	a	a	16,18
29	TRANSCO	Feasibility study, request to DOE for $1.9 x 10^6	Lurgi	125 x 10^9 Btu/day at 300-400 Btu/std ft^3	Commercial	East Texas lignite	a	Near Houston, Texas	a	a	23
30	Exxon, Carter Oil Co. (East Texas Coal Gasification Project)	Conceptual stage, unit to be operational in 1984-87	Lurgi	300 x 10^6 Btu/day, 925 x 10^6 std. ft^3/ day	Commercial, medium-Btu	Texas lignite	25,000 tons/ day	Gulf Coast, (near Baytown, Texas)	4000	a	17,24,25 26
31	Utah Resources International, Inc.	Preliminary EIS for coal-fired electric plant being revised for a gasification plant	Lurgi with methanation	275 x 10^6 ft^3/day	Commercial	a	17,000 tons/ day	Garfield Co., Utah	a	a	18

TABLE 5 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost $10^6	O&M cost	Reference No.
32	Mountain Fuel Company, Pacific Gas and Electric, Conoco	Planned completion in 1990, feasibility study under way	Lurgi with methanation	125 x 10^6 ft^3/day 125 x 10^9 btu/day	Commercial	Low-sulfur bituminous	9500 tons/day	Emery, Utah	1000	a	16,18
33	Texas Eastern Corporation	Preliminary feasibility study under way	Lurgi with methanation	275 x 10^6 ft^3/day	Commercial	a	30,000 tons/day	Wyoming	a	a	18
34	Rocky Mountain Energy, Pacific Gas and Electric, Bechtel, Southern California Edison	Feasibility study, funds requested from DOE, facility to start operation in 1987	Proven technology, including Lurgi	125 x 10^6 ft^3/day, equivalent to 7000 bbl oil/day	Commercial	Wyoming Cherokee	6 x 10^6 tons/yr	Southern Wyoming	a	a	10
35	Panhandle Eastern Pipeline Company	Plans for 1/2-size plant in holding stage, no filing as of February 1980, scheduled construction in 1982 and operation in 1986	Lurgi with methanation	270 x 10^6 ft^3/day, equivalent to 50,000 bbl oil/day	Commerical	Subbituminous	32,000 tons/day at full scale, 13,850 tons/day at 1/2-scale	Douglas (Converse Co.) Wyoming	1800	a	8,16,18, 27
36	Procon, Inc. DOE	Conceptual design study completed	HYGAS	a	Demonstration	a	a	a	7.5	a	18
37	Rockwell Corp. Cities Service Corp.	Pilot unit operating, demonstration unit planned	"Flash Hydropyrolysis"	a	Pilot and demonstration	a	25 tons/day for pilot unit, 100-250 tons/day for demonstration unit	a	12	$4/$10^6$ Btu	6

[a]Data not available.

[b]See text.

Applicable metric conversions:

10^6 Btu = 1.055 GJ
10^3 bbl = 159 m^3
10^6 scf = 26,300 Nm^3

TABLE 6. COAL LIQUEFACTION PROJECTS IN THE UNITED STATES

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost $10^6	O&M cost	Reference No.
1	Southern Company Services, Inc.; DOE, EPRI	Operational	SRC-PAMCO	a	Pilot	a	6 tons/day	Wilsonville, Alabama	b	b	1,28
2	Energy Systems Group, Rockwell International	Startup in August	Direct hydrogeneration	a	Pilot	a	0.25 tons/h, 6 tons/day	Canoga Park, California	b	b	28
3	Occidential Research Corp.	Tested in 1977	Flash pyrolysis	a	Process Development unit	a	3 tons/day	LaVerne, California	b	b	28
4	Oil Shale Corp. (TOSCO)	Constructed before 1978	TOSCO II	a	a		907 Mg/day	Grand Valley, Colorado	a	a	29
5	Lurgi, Badger Energy, W. R. Grace, DOE	Preliminary design	Texaco and methanation with Mobile	50,000 bbl gasoline/day	Commercial	a	a	Baskett, Kentucky	3	a	30
6	Ashland Oil, Airco, DOE	In preliminary phase, construction in 1983	H-coal	50,000 bbl/day	Commercial	a	a	Breckenridge, Kentucky	2000	a	5,31
7	Ashland Oil, Hydrocarbon Research	Pilot started in June 1980, commercial operation by 1990	H-coal	50,000 bbl fuel oil or syncrude/day from commercial unit	Pilot, demonstration, and commercial	a	Pilot unit: 600 tons/day, demonstration unit: 6000 tons/day; commercial unit: 20,000 tons/day	Cattlesburg, Kentucky	b	b	1,26,28, 34
8	Texas Eastern Synfuels, Texas Gas Transmission	Proposed construction (preliminary feasibility study)	Fischer Tropsch	Equivalent to 50,000 bbl oil/day; production divided into SNG (44%), transportation fuels (30%), and chemicals (26%)	Commercial	a	28,000 tons/day	Kentucky-Ohio Valley, (Henderson, Kentucky	4000	a	4,5,10,21

TABLE 6 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
9	Air Products & Chemicals, Inc.; Southern; Wheelabrator Frye	Proposed	SRC-I	20,000 bbl/day (possible expansion to 100,000 bbl/day by 1990)	Commercial/ demonstration	a	6000 tons/ day at 20,000 bbl/ day	Newman, Kentucky	1000[b]	b	1,13,32
10	Crow Indians, Fluor, Pacific Gas, Utah International, DOE	Feasibility phase	Sasol-III	65,000 bbl/day	Commercial	a	a	Billings, Montana	2000-4000	a	33
11	The Lummus Co., DOE	Startup in August 1977	Lummus Clean Fuel From Coal (CFFC) Process	a	Bench scale	a	30 lb/h	Bloomfield, New Jersey	b	b	28
12	FMC Corp., Office of Coal Research	Operational since 1970, dismantled in 1975	COED	0.4-1.5 bbl oil/ton coal	Pilot	a	36 tons/day	Princeton, New Jersey	a	a	1, 29
13	C&K Coal, Fluor	Conceptual design	Fischer-Tropsch	10,000 bbl/day	Commercial	High-sulfur Pennsylvania	4000 tons/ day	Clarion Co., Pennsylvania	a	a	23
14	U.S. Steel Corp., Texaco; Office of Coal Research	Operational	Clean coke process	a	Pilot	Illinois No. 6	100 tons/ day	Monroeville, Pennsylvania	a	a	1, 29
15	Tennessee Energy Institute	Initial planing completed; possible construction in 1983	a	150 x 10^6 gal/yr	a	a	a	East Tennessee	4000	a	6
16	Exxon Corp., Japan Coal Liquefaction Development Co., DOE	Under construction	Exxon Donor Process, liquid boiler fuel	a	Pilot	a	250 tons/ day	Baytown, Texas	a	a	1,28,34

TABLE 6 (continued)

ID No.	Sponsors	Status	Process	Production capacity	Scale	Type of coal	Coal feed rate	Location	Capital cost 10^6	O&M cost	Reference No.
17	United Coal of Bristol, Badger Energy, Monsanto, GE	Feasibility study	Mobil	1.2×10^6 gal gasoline/day	Commercial	High-sulfur	10,000 day	Virginia, near Clinch, New, or Holston River	700-800	$1/gal in 1985	6
18	Pittsburgh & Midway Coal Mining Co. (Gulf Oil), DOE	Operational	SRC-I, solid boiler fuel	a	Pilot	a	50 tons/day	Ft. Lewis, Washington	2.5[b]	b	1,28,32
19	Gulf Mineral Resources Co., DOE	Intermittent operation since July 1977	SRC-II	75 bbl/day	Pilot	a	30 tons/day	Tacoma, Washington	a	a	29,34
20	Fluor Engineers & Construction, Inc.; Am. Electric Power Corp.; Allegheny Power; DOE	a	Fischer-Tropsch	a	Pilot	a		Cresop, West Virginia	b	b	28
21	Japan, Gulf Mineral Resources Co.; Rhur Kohle AG/Steag AG	Under construction, operation scheduled in spring of 1984	SRC-II, liquid boiler fuel	20,000 bbl/day	Commercial	Eastern high-sulfur	6000 tons/day	Morgantown, West Virginia	1000[b]	a	1,31,34
22	Hampshire Energy, DOE	10-month feasibility study	a	20,000 bbl gasoline/day	a	a	15,000 tons/day	Gillette, Wyoming	b	a	4

[a]Data not available.

[b]See text.

Applicable metric conversions:

10^6 Btu = 1.055 GJ
10^3 bbl = 159 m^3
10^6 scf = 26,300 Nm^3

SECTION 3

ADDITIONAL INFORMATION AND COMMENTARY

The following commentary is offered on the projects identified in Section 2 for which additional information was available. The information presented can be found in the references listed on the summary tables. The commentary is based on both the data obtained from the references and assumptions based on knowledge of the projects. Some indication of the viability of certain projects was also obtained by contacting the licensors of the process.

The following projects are discussed in the same order as identified on the summary tables. Comments on Tables 4, 5, and 6 may apply to these descriptions, where appropriate.

LOW BTU GASIFICATION

1. Texaco, Southern California Edison (SCE) and EPRI are joint sponsors in this project. The plant is modeled after the Baskett, Kentucky pilot plant and is the first approval of an energy project in California under the 1978 California Coal Gasification Generation Act. The gasifier will be integrated with a combined cycle generator at a SCE facility and is likely to begin operation in 1983.

2. Combustion Engineering (CE), and other sponsors, received DOE funding to conduct approximately 2000 hours of operation at 75 percent loads in this 125 ton/day pilot plant. Total engineering, construction, and operating costs are shared by DOE and the industry sponsors; $\$16.6 \times 10^6$ from DOE and $\$8.3 \times 10^6$ from industry. The objective of the study is to demonstrate the process, determine the qualities of the gas, and provide a data base for commercialization of the process. The commercial-scale plant would be designed for 110 ton/h of coal to be used to generate 3000 MW of electricity.

3. Allis-Chalmers has the backing of 17 utilities and several government agencies in its Wood River Project. The rotary kiln process had been operated on a pilot scale since 1971 in Wisconsin and this project is now in the construction phase in Illinois. The gas produced will be used to reduce the consumption of other fuels at Illinois Power Wood River

Station. The plant is expected to begin operation in 1983. Allis-Chalmers hopes to demonstrate the abilities of the process and begin a major sales campaign by 1984.

4. The Appalachian Regional Commission expects that the 60 x 10^6 Btu/h plant will begin operation in 1981. The project was initiated in 1977 and issued a negative environmental impact declaration. Construction has been continuing since 1978. The project will supply fuel for boilers and process heaters in an industrial park, and hot water heating and cooling in a 65-acre development of dwelling units and community facilities.

5. General Refractories received $922,555 of the first $200 x 10^6 awarded by DOE for this nine month feasibility study.

6. Irwin Industrial Development, Inc. has delayed this project pending the resolution of environmental issues. A draft environmental impact statement (DEIS) was prepared in 1978 and the hearing board issued a report indicating that there were no technical problems, but some socioeconomic issues that must be resolved. Present status is unknown.

7. General Refractories Co. began preliminary engineering on the gasifier in 1977. A preliminary design report was issued in 1978. The fuel will be used to fire two tunnel kilns and twelve periodic kilns.

8. Combustion Engineering and Gulf States Utilities are expecting a $4 to $5 x 10^6 DOE grant for the design of a low-Btu gasification plant using the CE entrained bed process. The design will be similar to the pilot plant described in project 2, and will be located next to a Gulf States Utility plant. No definite information has yet been received on contract negotiations.

9. Central Main Power and the other firms are considering a $1 x 10^9 gasification plant using a Texaco gasifier and General Electric combined-cycle turbine generator. A request to DOE for $3.6 x 10^6 for a feasibility study on the project will in large part determine the outcome of this project. If the money is granted by September 1980, construction could begin in 1983. Without these funds, the project will probably be dropped.

10. Riley Stoker Co. has tested several coal types in the Riley-Morgan commercial size demonstration unit. One gasifier has been tested. Current status is unknown.

11. The Bureau of Mines, with partial funding by Department of Interior (DOI) and DOE, has completed some tests on this commercial size demonstration unit. Several coals were tested. The gas was used to fire an iron pelletizing kiln. Excess product gas was combusted. Current status is unknown.

12. Construction of the University of Minnesota gasifier was completed in 1978. Modifications to the gasifier were necessary and were completed in

1979. A second start up was also unsuccessful. The product will be used to fire steam boilers, and by-product tars will also be used as boiler fuel. The data sources show conflicting stages of development. Because of the necessary plant modifications, this project is probably not yet in the operating phase.

13. Lands O' Lakes, Inc. has encountered problems with their contractor's ability to obtain a bond. A new contractor was being sought in 1978. At the end of 1978, the company withdrew its application to Applied Technology Corp. to go ahead with the project. Investigation of a fluidized bed gasifier operating with lignite feed was begun. Current status is unknown.

14. National Lime and Stone Co. has been operating a low-Btu gasifier since 1955. The product gas is used to fire a lime kiln. Some lime scrubbing of sulfur components occurs within the kiln.

15-19. Glen-Gary Brick currently has eight gasifiers in commercial operation at brick kilns in five Pennsylvania plants. The product gas is used to fire the brick kilns.

20. Hazelton Brick Co. has four gasifiers in its brick plant. One gasifier is currently in use, three others are inactive. The gasifier, operating since 1953, produces low Btu gas for use in the brick kiln.

21. Binghamton Brick Co. has two gasifiers at its plant. The gasifiers are not currently in use.

22. Howmet Aluminum will have one gasifier when completed in 1980. The product gas will be used to fire process heaters. The possibility exists of adding up to 11 more gasifiers.

23. Can-Do, Inc. will have two gasifiers when the project is completed in 1980. The product gas will be used in an industrial park. Partial funding was obtained from DOE and the Department of Commerce (DOC). The possibility exists of adding two more gasifiers.

24. Caterpillar, Inc. started operation of a gasifier in October, 1979. The product gas will be used to fire process heaters.

25. Bituminous Coal Research, Inc. is developing the TRI-GAS process under the auspices of DOE using a multiple fluidized bed gasifier. A process development unit was tested in 1979. The tests were successful although minor equipment malfunctions occurred. The reactors were then disassembled for inspection and repair to the heaters. DOE is funding the effort for $\$2.6 \times 10^6$.

26. Westinghouse Electric Corporation is developing an advanced coal gasification system for electric power generation. The purpose of this project is to conduct laboratory research to refine the process, design and

construct a process development unit with a capacity of 15 ton/day, and operate the unit to establish operating characteristics for the design and construction of a commercial scale unit. The first test was conducted in November, 1978, and subsequent tests have been conducted since that time. The Department of Energy and industry share the cost of the project: 38.1×10^6 from DOE and 4×10^6 from industry.

27. The Holston Defense Corporation has been operating 12 gasifiers since 1940. The product gas is used to fire process heaters. Only two gasifiers are required at one time to meet the demand. Byproduct tar is used with coal to fire a steam boiler.

28. Allis-Chalmers has been operating a pilot plant since 1971. The data generated were used to design Project 3.

29. Gulf is conducting a five year study focused on in-situ gasification in seams that decline so steeply that they are not minable. A 40 day test conducted during the latter part of 1979 was reported to be successful. The Department of Energy granted over 12×10^6 for the project; Gulf contributed $750,000.

HIGH BTU GASIFICATION

1. Tennessee Valley Authority owns an ammonia plant that had been using natural gas as a feedstock. This project will substitute synthetic natural gas for 60 percent of the feedstock. The project calls for replacing the ammonia feed with the gasification product. TVA claims this as the first U.S. project to replace natural gas with synthetic gas in a commercial plant. Costs are broken down as: coal handling/preparation, 5.3 percent; wet grinding, 2.7 percent; coal gas, 9.5 percent; acid gas removal, shift conversion, and sulfur recovery, 37.1 percent; waste water treatment, 10.1 percent; slag disposal, 1.2 percent; air separation plant, 13.5 percent; control room, 8.1 percent; services, utilities, and ammonia plant modification during preliminary operation; 5.4 percent; common costs and administration, 1.4 percent.

2. Tennessee Valley Authority awarded 2.7×10^6 to the sponsors of this project to conduct the conceptual design studies of available gasification technology. Tennessee Valley Authority hopes to choose a process for final design and construction to satisfy a significant portion of industrial energy demand in Tennessee as well as providing fuel for electric power generation. The site has been selected and preliminary work is under way.

3. Arkansas Power is considering a pipeline quality gasification plant. Major industry in the area shows some interest in the project. Feasibility study funds were requested from DOE but were not granted in the first allocation. No information is available on the dependence of this project to the DOE grant.

4. Occidental Research and Development Co. is testing a bench scale process development unit using the Garrett process. The process appears feasible and tests have shown successful operation.

5. Pacific Gas and Electric has requested DOE support for a 70-week feasibility study assessing the Texaco and Lurgi gasification process. The study is projected to cost $\$4 \times 10^6$. No funds were granted in the first DOE allocation. The project is contingent on receiving grant money. The product could be used as pipeline gas.

6. The Institute of Gas Technology is developing the HYGAS process in a DOE and Gas Research Institute program. The gasifier began operation in 1973 and has been tested ever since using a variety of coals. Tests conducted have demonstrated the very high carbon conversion necessary for commercial operation. The process appears to be feasible in commercial application. The Department of Energy is contributing $\$15.1 \times 10^6$ and Gas Research Institute (GRI) $\$7.6 \times 10^6$ for design, construction, and operation of the plant.

7. Columbia Gas exchanged a 50 percent interest in 43,900 acres of its 300,000 acres of West Virginia coal lands for a 50 percent interest in 35,000 acres of Illinois coal lands held by Exxon-Carter Oil Co. The Illinois coal is being held by Columbia for coal gasification pending development of an economical and technically sound process. No specific plans are known to date.

8. Illinois Coal Gasification Group has received $\$22.5 \times 10^6$ to design a demonstration plant. Design for the facility is now being completed. The facility will integrate COED fluidized bed pyrolysis technology with the COGAS process. The COGAS process was recently piloted in a plant in England. Process development is sufficiently developed to serve a useful role in the synthetic fuel industry.

9. Texas Gas Transmission Corp. has completed initial feasibility studies for the HYGAS process. Coal reserves have been obtained and project planning continues. Some participation by federal and state governments is expected by the company.

10. Texaco and Houston Natural Gas requested $\$66 \times 10^6$ from DOE for a feasibility study of a coal gasification plant and a methanol plant adjacent to Texaco's oil refinery. Private funds were also solicited. The Department of Energy granted only half of the funds requested for the methanol plant portion. The status of the gasification project is not certain.

11. Mountain Fuel Resources and other sponsors are considering construction of a high-Btu gas and methanol plant. Economic and environmental feasibility studies are currently underway. A $\$12 \times 10^6$ request was made to DOE. No feasibility study funds were granted in the first allocation. State pre-qualification approval of the site has been received. Given the level of effort by this group of sponsors, the project appears viable.

12. Montana Power is considering construction of a gasification plant for 3 or 4 U.S. Air Force bases in Montana. Filings for permits have been made with the State Department of Natural Resources and Conservation. Private support is required for the project to become a reality; no DOE funds have been requested. Proposals for feasibility studies are currently being reviewed by the U.S. Air Force. The Company hopes to get as much as $\$160 \times 10^6$ from the U.S. Defense Department.

13. A DOE contract was awarded to Stearns-Rogers in October 1977, involving modifications and operation of an existing pilot plant. The plant had been operated under a Bureau of Mines contract. The Department of Energy granted $\$1.5 \times 10^6$ for the present contract. More current status of the project is unknown.

14. The Dunn Center Project had a previous water permit application denied in June 1976. A new application is being prepared. The Phase I engineering is complete. Further action has been deferred.

15. The Great Plains Gasification Association project is eminent. Construction is scheduled to be completed in 1984, but delays are being experienced due to disagreements of proposed rate payers' financing of the facility. A $\$22 \times 10^6$ cooperative agreement was granted by DOE in the first allotment. The plant is being built in 2 phases, with the first phase being one half the size of the full scale commercial project. The gas will be pipeline quality.

16. Texas Eastern Transmission and Pacific Lighting Corp. has proposed the (WESCO) project for Northwest, New Mexico. Continuation of the project is pending Federal Energy Regulatory Commission (FERC) certification, enactment of a federal loan guarantee program and plant site leasing from the Navajo Indians.

17. Texas Eastern Synfuels and Utah International, a subsidiary of G.E., are undertaking a 9 month feasibility study of a gas and methanol plant in New Mexico. Although not originally planned, a request was made to DOE for $3,018,000. The funds were granted in the first allocation and the study continues. General Electric holds one billion tons of coal reserves in the state.

18. El Paso Natural Gas and Pacific Gas & Electric Co. plan to construct a 1/4 of full scale plant on the Navajo Indian Reservation. The plant site lease is under negotiation. FERC is currently withholding approval pending resolution of matters pertaining to the acquisition of satisfactory commitments for coal.

19. Battelle has recently constructed a self-agglomerating ash pilot plant and has conducted limited testing. Additional testing is continuing to generate data needed to evaluate the process.

20. The Texas Eastern Corp. project in the Ohio Valley is currently in the feasibility study phase. The plant would produce a mix of gas, transportation fuels, and chemicals.

21. DOE has awarded a $40 x 10^6 contract to the sponsors to design this facility. Conceptual design is complete and the demonstration plant is being designed. The demonstration plant is expected to operate 3 1/2 years. Four gasifiers will be used.

22. Bituminous Coal Research and other sponsors are operating a pilot plant to develop a method for producing high Btu pipeline gas. The project is sponsored by DOE. In February 1978 a line ruptured and the gasifier depressurized, resulting in a fire. By June 1979 all fire damage had been repaired and additional testing is again scheduled. DOE is funding the project at $44 x 10^6; AGA contributes $22 x 10^6.

23. The Lummus Company has been operating a government owned SYNTHANE process gasifier since 1976 under a DOE contract. Following an instrument air failure in 1978, an explosion occurred in the high pressure boiler. The project was put on standby in 1979 due to lack of funds and has since ceased operation. A final report on the project is in preparation.

24. Dravo recently built a Hydrane process development unit for DOE. The bench scale unit was operated until the contract expired; originally scheduled expiration date was in 1978.

25. Philadelphia Gas Works was awarded $1,168,108 from the first DOE allocation for a 12 month feasibility study.

26. Conoco Coal Development Co. constructed the pilot plant in 1972. Forty-two runs were conducted on a variety of coals until the fall of 1977. Testing was then discontinued, having demonstrated the technical feasibility of the process. The pilot plant has been modified for testing the Westinghouse gasifier process.

27. Memphis Light, Gas, and Water was awarded $11 x 10^6 to design a commercial plant for producing industrial gas. All designs are complete and construction is scheduled to start in October 1980. The site has been designated a flood plain, and federal regulations require the sponsors to show there is no reasonable alternative. If the issues are resolved the plant will go into operation in 1984.

28. Exxon has been performing bench scale tests on their process, Exxon Donor Solvent (EDS). Feasibility studies on a commercial size plant have been completed. Construction of the plant has been deferred.

29. Transco is planning to build a coal gasification plant for electrical generation. A request of $1.9 x 10^6 was made to DOE but no funds were granted in the first allocation. Current project status is unknown.

30. The East Texas Coal Gasification project has completed the conceptual design of a gasification plant for supplying chemical feedstock and

process heating fuel. If the project continues, it is planned to be on-stream between 1984-1986.

31. Utah Resources International Inc. has leased acreage with nearly 0.5 billion tons of coal. A preliminary EIS which had been filed for a coal-fired electric plant, is currently being modified for a coal gasification plant.

32. Mountain Fuel and other sponsors are considering constructing a plant in Utah. A request for 2×10^6 had been made to DOE for an 18-month feasibility study, but no funds were granted in the first allocation. The economic and environmental feasibility studies are underway. No FERC filing has been made but the State has given prequalification approval of the site. This is the second plant announced by CONOCO, one of the sponsors.

33. Texas Eastern Corp. has a preliminary feasibility study under way for a plant in Wyoming.

34. Rocky Mountain Energy and other sponsors are planning to study the feasibility of a pipeline quality gasification project. A DOE request of 4×10^6 was made, but no funds were granted in the first allocation. The study is scheduled for completion in 1982 with possible plant start-up in the late 1980's. Continuing status is unknown.

35. Panhandle Eastern Pipeline Co. (Wycoal Gas Co.) has recently reactivated its plans for a pipeline gasification plant. They plan to file with the FERC for a rolled in ratepayer pricing; that plan met with oppposition in another project. A request was made for cooperative agreement funds of $\$100 \times 10^6$. DOE awarded $13,155,000 out of its first allocation. Full production activity is expected by 1988.

36. Procon, Inc. was awarded a 2 year, $\$7.5 \times 10^6$ contract for conceptual design of a commercial plant and process design and economic evaluation of a demonstration plant. Conceptual design is completed, and the process design and economic evaluation was finalized in April 1979. A final report is to be issued shortly.

37. Rockwell Corp. and Cities Services Co. have signed a long term agreement to develop and commercialize a flash hydro-pyrolysis technology. Rockwell has built 2 process demonstration units and hopes to begin construction of a pilot plant later this year.

COAL LIQUEFACTION

1. Southern Company Services has been operating a pilot plant for several years to provide data for a larger pilot plant. The results of tests are correlated with the Ft. Lewis plant (Liquefaction Project 8). A variety

of coals have been tested and the effects of process variables on yield and quality have been investigated. Based on the individual tests, improvements are then made to the SRC II process. The work, partially funded by DOE, will continue for several years. Total DOE funding is 8.7×10^6.

2. The Energy Systems Group of Rockwell International is developing a process to partially liquefy coal via direct hydrogenation. Phase I involved cold flow demonstration of transport and injection of pulverized coal into the reactor as a dense fluidized solid. A 0.25 ton/h reactor was tested in Phase II. A one ton/h reactor was built and tested in Phase III. Phase IV consists of configuration decisions for equipment and additional testing in a 4 ton/h unit. Phase IV was scheduled to begin in April 1980. The project is supported by DOE with $994,375.

3. The Occidental Research Corporation is evaluating the commercial potential of its flash pyrolysis process. An existing 3 ton/day process development unit was modified and improved, upon receiving DOE funding (100% funding by DOE = 3.8×10^6). Testing was performed in 1977 on a variety of coals. Two major technical problems were encountered and solved: tar yields were low compared to projections, and poor char rate control severely limited the reactor operability. The final report on the project is due soon and it appears the project is complete.

4. The Oil Shale Corporation has applied the technology of oil shale retorting to low temperature carbonization of coal. The pilot plant processes subbituminous coal at the Rocky Flats Research Center. A low sulfur char product of half the weight of coal and a low sulfur liquid fuel are produced.

5. W.R. Grace plans to build a plant which yields high octane gasoline by first converting coal in a Texaco gasifier, then to methanol and finally gasoline using the Mobil process. DOE is backing the project with $12-16 \times 10^6$ for initial design of the facility and DOE officials expect to support it into the commercial phase.

6. Ashland and Airco signed a contract with DOE for 7.5×10^6 for preliminary engineering of this commercial facility. Groundbreaking is scheduled for 1983, production in 1987. The final decision to go ahead with the project will be based on the success of the Cattlesburg pilot plant (see Project 7).

7. Ashland Oil began operation of a pilot plant in June 1980. The coal feed system had to be modified shortly after start-up and has since been reported to be running smoothly. An H_2S monitoring system is being designed for the plant. DOE is currently funding the project for 258×10^6, excluding the cost of the plant. The pilot plant is scheduled to operate until the end of 1982.

8. Texas Eastern Synfuels has won more first allocation DOE grants than any other named sponsor. Kentucky officials are negotiating with landowners for a 1500 acre site for a proposed plant. The funds were granted for a cooperative agreement and amounted to over 24×10^6. Approximately 44 percent of the output will be synthetic natural gas, 30 percent transportation fuels, and the remaining amount will be chemical feedstocks. The plant will require 35,000 acre-feet of water/day.

9. Air Products, who built the plant in project 1, is in the final engineering phase of a commercial scale demonstration plant. The company estimates that 144×10^6 for a 12,000 ton/day oxygen plant is required to support a 50,000 ton/day coal conversion facility using the Lurgi gasifier and the Fischer-Tropsch liquefaction technology. If all goes well, the demonstration plant will be expanded to 100,000 bbl/day by adding four additional units. The original cost estimate came to 700×10^6. The product will sell for $36/bbl, of which $28 is for capital cost, $5 for coal purchase, and $3 for labor.

10. The Crow Indians have reached agreement with Fluor Construction to build a plant on the reservation. A proposal for DOE funding is being prepared. The Council on Energy Resource Tribes has already completed major environmental analyses for the project.

11. Lummus is studying its Clean Fuel From Coal Process under a DOE contract of 4.7×10^6. The bench scale gasification pilot plant became operational in 1972. The hydroliquefaction unit was started in August 1977. All experimental work was completed by June 1979 and the final report is being prepared.

12. The FMC Corp. had been operating a pilot plant since 1970. The project, however, was stopped and the plant dismantled in 1975.

13. C&K Coal is planning to build a liquefaction plant in Pennsylvania. The company holds over 65×10^6 tons of high sulfur coal in western Pennsylvania. The company is currently applying to DOE for funds to conduct the feasibility study.

14. U.S. Steel Corporation has developed a liquefaction process. An initial DOE contract was awarded in 1972 to design and operate a pilot plant. Laboratory and bench scale development studies had been conducted since 1969. The process development unit was built and tested to obtain the data required to design the 100 ton/day pilot plant.

15. The Tennessee Energy Institute is moving towards construction of a synthetic gasoline plant. A request was made to DOE for 4×10^6 for the initial planning. No funds were granted in the first allocation. The Institute may also ask the department to back a bond issue for the plant.

16. Exxon has developed the Exxon Donor Solvent process and is under contract with DOE to design and operate a 250 ton/day pilot plant. A one ton per day plant was constructed and has been tested since 1976. The 250 ton/day plant was completed in September 1980. A screening study to

determine the concentration and composition of metals contained in the products has been completed. Preliminary economic studies have begun.

17. United Coal of Bristol, Tennessee has submitted a $4 x 10^6 grant application to DOE to study the feasibility of a synthetic gasoline plant in Virginia. No money was granted in the first allocation, but the project is also backed by industry and the newly formed Virginia Fuel Conversion Authority. The status of the feasibility study is unknown. Initial projections put startup in 1985 with production costs equal to $1/gallon of gasoline.

18. Pittsburg and Midway Coal Mining Company are operating a pilot plant similar to project 1 to continue to develop a data base on the process for eventual commercial scale-up and to provide samples of solvent-refined coal and byproducts for market development studies. The unit became operational in 1974 and is scheduled to continue operation through 1981. Total funding for the project is $88.8 x 10^6.

19. Gulf Mineral Resources Co. has operated a DOE pilot plant intermittently since July 1977. Earlier development included bench scale tests and operation of a process development unit. EPRI feels that the pilot plant can be advanced to a full-scale demonstration unit one or two years sooner than the H-coal or EDS system. DOE has recently given Gulf a contract for preliminary engineering of 6,000 ton/day plant which is planned to be operational by 1983. EPRI feels this timetable is reasonable.

20. Fluor Engineers and Constructors were under a $66 x 10^6 DOE contract to renovate a DOE owned facility in Cresap, West Virginia. The facility has been inactive since 1970 and contains much of the equipment required for coal liquefaction. The renovated facility was being operated to produce a low-sulfur liquid fuel. The plant was shut down in May 1979 and was completely deactivated in September 1979, when the contract terminated. A draft report is being prepared.

21. Gulf Minerals is planning to construct a 6,000 ton/day plant in Morgantown based on the pilot plant (Project Number 19). An air quality permit application was scheduled to be filed in early 1980 and an environmental impact statement issued in late 1980. The construction is scheduled to begin in the Spring of 1981 and be completed by 1984. The original capital cost estimated was $700 x 10^6 in 1978.

22. Hamphire Energy of Milwaukee, Wisconsin has received $4 x 10^6 from DOE's first grant money allocation. A feasibility study will be performed for a gasoline plant in Wyoming. No further details are available.

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